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Environment and Development in Coastal Regions
and in Small Islands (CSI)

**APPLICATIONS OF SATELLITE AND AIRBORNE IMAGE DATA
TO COASTAL MANAGEMENT**

Seventh Computer-based Learning Module
(*Bilko for Windows*)



Applications of Satellite and Airborne Image Data to Coastal Management

Seventh Computer-based Learning Module
(*Bilko for Windows*)

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A CONTRIBUTION TO "AGENDA 21" IMPLEMENTATION

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intended for publication in the CSI Info series;
for use in other products, consult UNESCO-CSI
by electronic mail to admin@unesco.bilko.org

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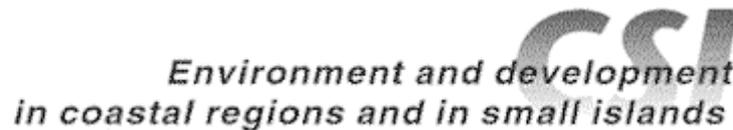
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PREFACE

The majority of the world's population live in coastal regions. Increasing competition for the diminishing resources in coastal areas and the growing disparity between those who have and those who have not, make coastal belts potential flash points for resource conflict. Often these conflicts may be between, on the one hand the pressures of global tourism, poorly implemented industrialisation, or inappropriate aquaculture developments, and on the other, local communities dependent on coastal resources who find these threatened by such external forces. To manage such coastal areas is a unique and complex challenge. Integrated coastal management (ICM) seeks to rise to this challenge by co-ordinated planning and action involving communities, stakeholder groups and managers at local, regional and national level as well as both natural and social scientists.

As a first step to coastal management and planning, managers need to map existing coastal habitats and resources and determine how these relate spatially to areas of urban, industrial, aquaculture, tourism and other developments. This allows sites of potential conflict, high biodiversity, inappropriate development, high sensitivity to environmental impacts, etc. to be identified and for management initiatives and scarce resources to be targeted accordingly.

The primary tool for mapping coastal habitats and resources is remote sensing using satellite sensors and, increasingly, airborne digital scanners. This remote sensing distance-learning module, the seventh in the *Bilko* series, focuses on these coastal management applications. In eight practical lessons it gives users a thorough grounding in a suite of coastal management related remote sensing tasks, ranging from acquisition of appropriate imagery and interpretation of coastal images, through radiometric and water column correction, to mapping of coastal marine habitats and quantitative assessment of seagrasses and mangroves. The module seeks through its training to improve the quality of spatial data available to coastal managers and planners and thus ultimately to improve the management of the coastal resources on which local communities depend.



INTRODUCTION

This is the seventh computer-based learning module prepared in UNESCO's *Bilko* project and the first developed to address the objectives of the Environment and Development in Coastal Regions and in Small Islands programme (CSI: <http://www.unesco.org/csi>). It is the second to use a Windows based version of the BILKO software (*Bilko for Windows*). Like its predecessors which used versions of the original MS-DOS based BILKO software (Modules 1-5: obtainable from <http://www.unesco.bilko.org/>) and an earlier version of *Bilko for Windows* (Module 6), it contains a series of lessons based on the display of data in image form and it demonstrates the processing and interpretation of these images using *Bilko for Windows*. Unlike earlier modules, Module 7 requires that *Excel* (or a spreadsheet package which can read *Excel* files) also be installed.

Coastal management

Unlike previous modules, which had a more broadly based focus, Module 7 is strongly orientated towards coastal management applications in tropical countries.

Habitat maps derived using remote sensing technologies are widely and increasingly being used to assess the status of coastal natural resources and as a basis for coastal planning and for the conservation, management, monitoring and valuation of these resources. Digital sensors commonly used for coastal management applications have spatial resolutions ranging from about 1-80 m and spectral resolutions ranging from a single panchromatic band to around 16 precisely defined wavebands which can be programmed for specific applications. Costs of imagery range from about £0.25k for a low-resolution (80 m pixel) satellite image covering 35,000 km² to perhaps £80k for a high-resolution (3 m pixel) airborne multispectral image covering less than half this area. In addition, high-resolution analogue technologies such as colour aerial photography are still in routine use. Coastal managers and other end-users charged with coastal planning and management and the conservation and monitoring of coastal resources require guidance as to which among this plethora of remote sensing technologies are appropriate for achieving particular objectives. To this end the UK Department for International Development (DfID) have funded production of a *Remote Sensing Handbook for Tropical Coastal Management*. Module 7 complements this *Handbook* by providing training for practitioners on *how* to carry out key image processing steps that are particularly important for coastal management applications. It also guides practitioners in the mapping of coral reef, seagrass and mangrove ecosystems and the quantitative assessment of the status of the latter two resources using airborne and satellite imagery.

The satellite and airborne images used in this module are all of the Caicos Bank area of the Turks and Caicos Islands which lie to the south-east of the Bahamas. This area was chosen as a test site to discover what coastal management objectives are realistically achievable using remote sensing technologies and at what cost. This site offered good clear-water conditions, a broad mix of coastal habitat types, a very large area (>10,000 km²) of shallow (<20 m deep) coastal waters which would be amenable to the technologies. Module 7 builds on the experience gained in our investigation for DfID of the capabilities of the range of sensors in wide current use. The objectives of using remote sensing should always be clearly defined so that appropriate imagery is obtained and adequate processing is carried out. The objectives of coastal managers in using remote sensing are listed below.

Uses of remote sensing in the coastal zone

Worldwide, sixty coastal managers and scientists (out of 140 contacted) responded to a questionnaire in which they were asked a) to identify what they saw as the primary applications of remote sensing and b) to prioritise the usefulness to them of various levels of information on coastal systems.

The most in-demand applications of remotely-sensed data were to provide background information for management planning and to detect coastal habitat change over time (Figure 1). The term “background information” reflects the vagueness with which habitat maps are often commissioned and indicates a need for objectives of remote sensing surveys to be defined more rigorously. 70% of respondents who were using remote sensing for change detection were concerned with mangrove assessment and/or shrimp farming. The primary uses made of the habitat/resource maps are shown in Figure 1.

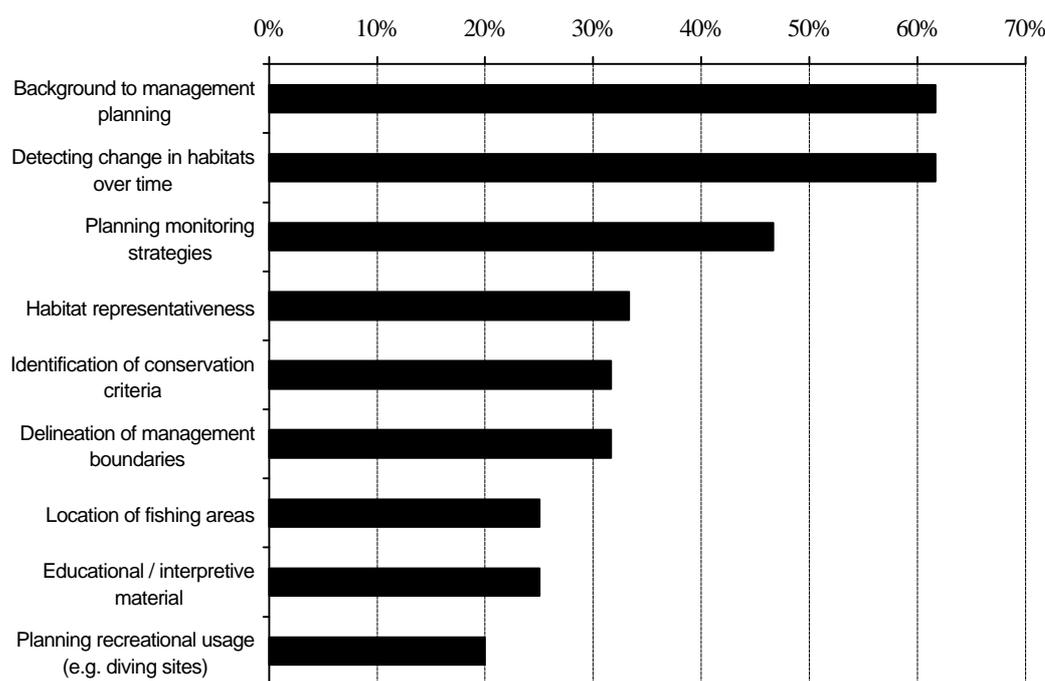


Figure 1. Responses of 60 coastal managers and scientists to a questionnaire asking them to identify what they considered the primary applications of remote sensing for tropical coastal management.

Getting started: The full list of files needed for Module 7 is detailed in Appendix A.

The minimum recommended level of computing hardware is a Personal Computer with a reasonably fast (e.g. 66 MHz) 486 processor and 16 Mbytes of memory which is running under Windows 3.1 or later. For computers running Windows 95 a Pentium with 16 Mbytes of memory is recommended as the minimum specification. However, we have run the software successfully on PCs with only 8 Mbytes of memory. About 60 Mbytes of free disk space is required for all the lesson documentation and images. A graphics card which can display 16-bit colour images (High colour) is required to view colour composites. The lessons are available over the World Wide Web (<http://www.unesco.bilko.org/>) and on CD-ROM.

Lesson texts and other documentation are available as Microsoft Word (.doc) and Adobe Acrobat (.pdf) files, which you can print from disk or edit to suit your specific training and educational needs.

Use of the module: Just one condition and one request are attached to the copying and distribution of the material in this module. The condition is that **the material may not be sold**. The request is that if you make use of this module, either the original or a copy, you fill in the reply sheet and return it to the

UNESCO-Bilko Project Coordinator, c/o ITC, Enschede, at the address indicated. The return of reply sheets helps us to assess whether our modules are reaching the community for which they are intended, and so serves as a guide in preparing new lesson material for future modules. A reply sheet is attached to the letter accompanying this module and it is reproduced on page 185.

Perspective: It is now over ten years since the first memoranda on what has become the *Bilko* project were circulated. For those of us who have been involved with the project since its inception, it was a pleasure to experience the warm reception accorded the first module and a relief to see the steady growth of the small community of interested teachers and researchers as subsequent modules were published. We now have lessons from all five continents and the present module will be available worldwide over the internet.

With the increasing number of lessons has come an increase in the community which surrounds the *Bilko* project. The first module was written by the founding group and distributed to colleagues known at UNESCO to be interested in the teaching of marine sciences. Recipients were asked to make copies freely available to colleagues and students, and to consider writing a lesson for publication in a future module. The number, quality and variety of the lessons received are evidence that the recipients are not content merely to use the materials provided, but do indeed think it worth while to contribute to this exercise in improving the quality of teaching.

Since its earliest days, the prime objective of this project has been, by example, to promote excellence in teaching. This is a demanding task, but the reports on existing modules are good. We are aware, however, of two shortcomings relative to the original goals: lessons, while extensively reviewed and edited, have not usually been subjected to the extensive student testing that is normally a prominent feature in the development of computer-based lessons, and the range of topics covered remains narrower than it need be given the power of the existing software.

Development: An initiative is now in hand to extend the concepts developed in the earlier *Bilko* modules and develop web-based lessons which can be run over the internet. These will build on the concepts embodied in the Windows Help file lessons developed for Module 6, will be easier for lesson creators to write, will retain the advantages of hypertext links, and will offer more interactivity as HyperText Markup Language (HTML) and Java develops.

You too can contribute: One purpose in writing this introduction is to ask your help. The project is open to development along three broad lines which may be described as relating to access, excellence and community. All are asked to take part in this development, but key contributions will come from those who teach their students using the lessons and offer their experience for the benefit of others.

The writing of *Bilko for Windows* is an important development. We know that their experience in the classroom has led many teachers to add their own questions and refinements to the published lessons. Our objective is to enrich these lessons by pooling the knowledge that already exists in the network of *Bilko* users. For this, we'd like questions, descriptions of student projects, alternative images and alternative presentations. Please do not hesitate to send exercises, modifications or additional explanations which have worked well with your students. It is a simple matter to link optional text to the main lessons, and we hope to add several tens of exercises to the published versions of existing modules.

All types of lessons are welcomed, provided they are based on data that make use of the *Bilko for Windows* software. If you would like to contribute a lesson, note that Section 3 of Module 2 contains a "Lesson for Lesson Creators" which provides guidance on the preparation of images and texts. As with most scientific educational literature, contributed lessons are subject to editorial review before publication. To find out more, a useful first step is to fill in the reply sheet at the end of this module. If you would like to discuss the matter informally, do not hesitate to contact any member of the development team.

Other modules: If you find this module interesting and would like to obtain copies of others in the series (written for the MS-DOS version of *Bilko*), these are downloadable over the internet. See World Wide Web address <http://www.unesco.bilko.org/> for further details or write to (or e-mail) the UNESCO-Bilko Project Coordinator, c/o ITC, Enschede at the address given on page 185. The contents tables of these earlier modules can be browsed over the internet at the address above and are also reproduced in Appendix B.

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On-line Introductory Tutorials

The on-line introductory tutorials consist of nine lessons which have been written to help you to learn how to use the Unesco *Bilko for Windows* image processing software. *Bilko for Windows* makes use of a number of document types which enable you to interact with image data. Each lesson introduces a different type of document, and the various operations and functions associated with it. As a prelude to a series of on-line lessons in satellite oceanography, each tutorial lesson uses a different satellite image of the sea. Although no direct instruction is given in oceanographic interpretation, by the time you reach the end of the Tutorials you will already have gained some experience of marine image data. The Tutorials cover similar ground to the text based Introduction to *Bilko for Windows*.

To start the Introductory Tutorials double-click on the file named IN_TUT00.HLP in **File Manager** or **Windows Explorer** or use the **File, Open** command to open it. All the other lessons can be accessed from this file.

On-line introductory tutorial lessons.

Lesson	Topic
Lesson 1	Opening and viewing images
Lesson 2	Learning about transects
Lesson 3	Histogram documents
Lesson 4	Stretch documents
Lesson 5	Palette documents
Lesson 6	Filter documents
Lesson 7	Connect multiple images
Lesson 8	Scatter documents
Lesson 9	Formula documents

Note: These on-line tutorials were written for use with Windows 3.1. Windows 95/98 and NT users should take account of this and be prepared for minor differences due to the operating systems used.

Use the <ALT>+<TAB> key combination to switch between *Bilko for Windows* and the on-line tutorials if you have a small (14-15") monitor. Alternatively, if you have a larger monitor, place the tutorial lesson window at the top right of the screen and size it so that it does not obscure too much of the screen. Then set the **Help, Always on Top** option (Windows 3.1) or **Options, Keep Help on Top** (Windows95/NT) on so that you have the lesson available as well as your *Bilko for Windows* workspace.

Comments or suggestions relating to these tutorials should be sent to:

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Section 2

Practical lessons using coastal image data of the
Caicos Bank

Applying Remote Sensing to Coastal Management Issues

The lessons in Module 7 are designed to aid the training of remote sensing practitioners in developing countries who are working with coastal images and want to gain the most from their images. The primary aim of the lessons is to promote an understanding of the principles of the various techniques involved and to develop the student's critical faculties in terms of assessing whether remote sensing technologies are likely to be useful in achieving defined objectives. Some of the lessons are fairly straightforward (Lessons 1, 2 and 6), others guide the student through some complex and difficult areas of image processing (e.g. Lessons 3, 4 and 5), and others introduce relatively simple techniques which are nevertheless at the forefront of applied remote sensing and can greatly enhance the usefulness of imagery to coastal managers (e.g. Lessons 7 and 8).

Lessons 1, 2 and 7 were drafted by Dr Peter Mumby and Lessons 3, 4, 5, 6 and 8 were written by Dr Alasdair Edwards who then edited all the lessons for consistency of style. All lessons drew heavily on chapters from the *Remote Sensing Handbook for Tropical Coastal Management* (Green, E.P., Mumby, P.J., Edwards, A.J. and Clark, C.D., in press). Specific chapters in the *Handbook* where the skills learnt in each lesson can be followed up are indicated in the lessons. The lessons attempt to follow a logical sequence of image interpretation and processing.

Thus **Lesson 1** allows you to get to know the study area in the Turks and Caicos Islands from where the images were acquired and concentrates on visual interpretation of imagery using colour composites. It also seeks to build your ability to link what is on the images to actual habitats on the ground (or in the sea!) and to indicate how remotely sensed imagery can be used to guide field survey. **Lesson 2** focuses on the importance of acquiring images of an appropriate scale and spatial resolution to meet your objectives. In the lesson you estimate the size of a range of habitats and man-made structures and then discover which image types are suitable for mapping these habitats or structures. **Lesson 3** is a specialist lesson and is probably the most complex of all. It explores the radiometric correction of imagery which is necessary if you are trying to monitor change or are just working with more than one image and seeks to show why radiometric correction (including atmospheric correction) is necessary for certain applications and how to carry it out. **Lesson 4** is partly included as preparation for Lesson 5 which deals with how one compensates for the effect of water depth on bottom reflectance. It introduces you to the effects of water depth and how its influence on bottom reflectance is such that one can crudely map depth using optical imagery. **Lesson 5** then shows you how to compensate for the effect of water depth so that you can map submerged marine habitats with some degree of confidence. This very important processing step is often not done although, for imagery with more than two wavebands which penetrate the water column, it dramatically improves the accuracy of habitat mapping. **Lesson 6** takes the outputs of depth-invariant processing covered in Lesson 5 and uses these to illustrate the principles of habitat classification using a simple box-classifier. The **Lessons 7 and 8** show how one can quantitatively map seagrass standing crop and mangrove leaf area index (LAI) respectively using satellite and airborne imagery. The relatively simple techniques involved seem under-utilised. They use the same imagery to provide considerable additional information to coastal managers. This makes much better use of the imagery although some additional field survey work is required.

Hopefully, the lessons will stimulate better use of existing imagery and a better understanding of the processing steps required to achieve habitat maps of useful accuracy. The issue of accuracy of outputs is more fully explored in the *Remote Sensing Handbook for Tropical Coastal Management*.

To carry out the lessons successfully you need to have a good working knowledge of *Bilko for Windows* (obtainable by working through the Introduction and/or Introductory Tutorials - a few hours work which also serves to introduce you to a range of image processing techniques). Also for many of the lessons, a working knowledge of the spreadsheet *Excel* (or another *Windows* compatible spreadsheet) is required. Such knowledge is indispensable for anyone thinking of carrying out remote sensing.

Photographic credits:

A number of photographic images are made available in this module as .GIF files. Photographs were provided by Alasdair Edwards, Edmund Green, Peter Mumby and Jonathan Ridley. Those provided by Jonathan Ridley (Coral Cay Conservation) have image names prefixed with “CCC”.

Acknowledgements:

The research that underpins the lessons for this module was funded by the UK Department for International Development's Environment Research Programme. The Turks and Caicos Islands' Department of Environment and Coastal Resources provided invaluable logistical assistance during the field survey work required to ground-truth the images. Our thanks go in particular to Mr Christie Hall, Mr Chris Nannes, Dr Paul Medley, Mr Perry Seymore, Mr John Ewing, the staff and students of the School for Field Studies, and Ms Angie Ellis for their support in the field.

The module was field tested at the *IOC-UNEP Regional Training Course on Seagrass mapping using Remote Sensing* held at the Institute of Marine Sciences (IMS), Zanzibar, 24-28 November 1997. We would like to thank Ms Agneta Nilsson, UNEP Water Branch, Nairobi and Dr Julian Barbière, IOC, Paris for their organisation of this workshop and to thank all the Tanzanian and Kenyan participants at the workshop for their enthusiasm and valuable feedback on the module. This feedback from potential users was extremely useful in redesigning some elements of the software and improving the lesson materials. We thank the staff at IMS for their excellent technical support and hospitality which helped ensure the success of the training workshop. For further testing of the software and lessons we are grateful to Mr Mark Busby (Sheffield University), MSc Tropical Coastal Management students (Newcastle University), and members of the Bilko Project Steering Committee.

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Appendix A

Contents of Module 7

The programme file for *Bilko for Windows v. 2.0*, associated Help files, documentation, files containing images (.BMP, .GIF, .DAT and .BIN files), look-up tables (.STR files), palettes (.PAL files), formulas (.FRM files), and *Excel* spreadsheet files associated with some lessons, are either available on a CD-ROM distributed with this booklet or can be downloaded over the internet.

The total amount of free disk space required for all the files associated with Module 7 is about 60 Mbytes. The five *Word* document files making up the Introduction comprise about 15 Mbytes.

CD-ROM

1. Insert the compact disc into your CD-ROM drive.
2. In Windows 3.1 select **File, Run** from the **Programme Manager** menu and type **e:\setup** as the **Command line:** of the **Run** dialog box where **e:** is the drive letter of your CD-ROM drive.

or

2. In Windows 95/NT the installation should start automatically ('autoplay'). If you right-click the Bilko-CD icon in 'My Computer' the menu should include **AutoPlay**; if it doesn't, click on the **Start** button and select the **Run** option. In the **Open** dialog box, type **e:\setup** where **e:** is the drive letter of your CD-ROM drive or use the **Browse** menu to find the SETUP.EXE program on the CD-ROM. Then click on OK.
3. Follow the Install Shield instructions.

Note: All the files required for modules 1-6 are also included on the CD-ROM and may be installed if required.

Downloading over the internet

An "anonymous ftp" site has been set up from which all the files needed for Module 7 can be downloaded. All the files have been zipped to make them as small as possible. Even so the largest lesson is still 5 Mbytes in size so a reasonably fast internet connection is needed to download. You can either download using ftp or via some specially prepared web pages using a web browser. For details of where to find the files and how to download them you should visit the web page on URL:

<http://www.unesco.bilko.org/>

and fill in an electronic form which can be accessed from that page. You will then be e-mailed instructions on how to download the files.

Note: All the files required for modules 1-6 are also available in zipped form on the anonymous ftp site and may be downloaded if required.

The text of the Introduction and lessons for Module 7 is stored as a series of Word (6.0/95) document files (.doc) and Adobe Acrobat portable document files (.pdf). The Word files are formatted for a Hewlett-Packard Laserjet 6P printer and may need some editing if printed on other printers. The Acrobat files are formatted for A4 paper.

The contents of Module 7 are listed on the following pages under the section heading of the modules to which files belong.

Contents of Module 7

The CD-ROM and *Bilko* anonymous ftp site contain the programme WINBILKO.EXE and the help file WINBILKO.HLP used by all the lessons and exercises. They also contain all the documentation and other files required for the introduction, the on-line introductory tutorial, and the lessons themselves. In a number of lessons special *Trainers' reference files* are included to aid those using this module to train others. Document files are also available in Acrobat format (.pdf extension).

Programme	WINBILKO	EXE
	WINBILKO	HLP

Module introduction and appendices

Text file	MODULE7	DOC
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Section 1: Introduction to *Bilko for Windows 2.0* image processing software

Text files	INTRO1	DOC
	INTRO2	DOC
	INTRO3	DOC
	INTRO4	DOC
	INTRO5	DOC

Image files	EIRE2	BMP
	EIRE4	BMP
	TM1CC	GIF
	TM2CC	GIF
	TM3CC	GIF
	TM4CC	GIF
	CASI2INT	BIN

Accessory files	CASI2INT	STR
	EIRE4_T	STR (Trainers' reference file)
	EIRE4_T	PAL (Trainers' reference file)

Introductory on-line tutorials

	IN_TUT00	HLP
	IN_TUT01	HLP
	IN_TUT02	HLP
	IN_TUT03	HLP
	IN_TUT04	HLP
	IN_TUT05	HLP
	IN_TUT06	HLP
	IN_TUT07	HLP
	IN_TUT08	HLP
IN_TUT09	HLP	
Image files	GT_93MN	GIF
	IB_CHLOR	GIF
	SARDINIA	GIF
	S_ATLAN	GIF
	SARDS002	GIF
	GIR_SP1	GIF
GIR_SP2	GIF	

	GIR_SP3	GIF
	GIR861	GIF
	GIR862	GIF
	GIR863	GIF
	SST0290	GIF
	SST0890	GIF
Accessory files	CHLOR2	PAL
	GLOBTEMP	PAL
	GREY1	PAL

Section 2: Practical lessons using coastal image data of the Caicos Bank

Lesson 1: Visual interpretation of images with the help of colour composites: getting to know the study area

Text file	LESSON1	DOC
Image files	XS1SUB	GIF
	XS2SUB	GIF
	XS3SUB	GIF
	CASIHARB	GIF
Scanned photographs	MANG_AIR	GIF
	MANG_RMS	GIF
	MANG_RMT	GIF
	MANG_WHT	GIF
	MANG_BLA	GIF
	SEAG_DEN	GIF
	CCC_SND	GIF
	CASI_SEN	GIF
	COCKHARB	GIF
	BROWN_AL	GIF
	MONT_COL	GIF
	MONT_SVY	GIF
	CCC_PALM	GIF
	GORGPLAN	GIF
	SEAG_SPR	GIF
	BLOWOUT	GIF

Lesson 2: The importance of acquiring images of the appropriate scale and spatial resolution for your objectives

Text file	LESSON2	DOC
Image files	AP_MANG	GIF
	XPSUBSET	GIF
	MSS1	GIF
	MSS2	GIF
	MSS3	GIF
	CASIMANG	GIF
	XS1SUB	GIF*
	XS2SUB	GIF*
	XS3SUB	GIF*
	CASIHARB	GIF*
	AP_SCAIC	GIF

	TM1_SC	GIF
	TM2_SC	GIF
	TM3_SC	GIF
	AP_EAST1	GIF
Scanned photographs	BLOWOUT	GIF*
	SEAG_DEN	GIF*
	MONT_COL	GIF*

* Denotes files also used in Lesson 1.

Lesson 3: Radiometric correction of satellite images: when and why radiometric correction is necessary

Text file	LESSON3	DOC
Image files	TMNOVDN1	GIF
	TMNOVDN2	GIF
	TMNOVDN3	GIF
	TMJUNDN1	GIF
	TMJUNDN2	GIF
	TMJUNDN3	GIF
Accessory files	RADCOJUN	FRM
	RADCO1_T	FRM (Trainers' reference file)
	RADCO2_T	FRM (Trainers' reference file)

Lesson 4: Crude bathymetric mapping using Landsat TM satellite imagery

Text file	LESSON4	DOC
Image files	TMBATHY1	GIF
	TMBATHY2	GIF
	TMBATHY3	GIF
	TMBATHY4	GIF
	LANDMSK4	GIF
	BATHYMAP	GIF
Accessory files	DEPTHS	XLS
	DOPZONES	FRM
	DOP4ZONE	FRM
	DOP4ZONE	PAL
	BATHYMAP	FRM
	BATHYGRY	PAL
	BATHYBLU	PAL
	BATHYCON	PAL
	ZONE2_T	FRM (Trainers' reference file)

Lesson 5: Compensating for variable water depth to improve mapping of underwater habitats: why it is necessary

Text file	LESSON5	DOC
Image files	CASI3C16	DAT
	CASI4C16	DAT
	CASI2C16	DAT
	CASI5C16	DAT
	CASI2_4	DAT

	CASI3_5	DAT
Accessory files	DEEP	XLS
	CASI3	STR
	CASI4	STR
	CASISAND	XLS
	CASIB3B4	XLS
	CASI3_4	FRM
	DEPTHINV	FRM
	CASI34_T	FRM (Trainers' reference file)
	CASISA_T	XLS (Trainers' reference file)

Lesson 6: Mapping the major inshore marine habitats of the Caicos Bank by multispectral classification using Landsat TM

Text file	LESSON6	DOC
Image files	DI_TM13	DAT
	DI_TM23	DAT
	TMBAND5	GIF
Accessory files	HABITATS	XLS
	CLASSIF1	PAL
	CLASSIF1	FRM
	CLASSIF2	FRM
	HABITA_T	XLS (Trainers' reference file)

Lesson 7: Predicting seagrass standing crop using SPOT XS satellite imagery

Text file	LESSON7	DOC
Image files	XS_DI	DAT
	LANDMSK7	GIF
	SEAGMASK	GIF
	SEAGAREA	GIF
Accessory files	LESSON7	XLS
	STEP1	FRM
	STEP2	FRM
	SEAGRAS1	PAL
	SEAGRAS2	PAL
	LESS7_T	XLS (Trainers' reference file)

Lesson 8: Assessing mangrove leaf-area index (LAI) using CASI airborne imagery

Text file	LESSON8	DOC
Image files	CASIMNG6	DAT
	CASIMNG7	DAT
Accessory files	MANGNDVI	XLS
	LAI	PAL
	MANGND_T	XLS (Trainers' reference file)

Appendix B

Contents of First Module (MARINF/70, July 1989)

Introduction

Section 1: Introductory Tutorial: the BILKO Image Processing Software

Section 2: Practical Lessons in Satellite Oceanography

- Images of open ocean sea-surface temperature
- Thermal images of ocean fronts
- Coastal zone colour scanner data off Iceland
- Comparison of coincident AVHRR and CZCS data
- Shelf seas thermal structure
 - North Sea, early summer
 - Early summer stratification in the Irish Sea
- Airborne thematic mapper data- Southampton Docks

Section 3: Sea-Surface Temperature Exercise

Section 4: Further Action

Appendix: Contents of the floppy disks

Contents of Second Module (MARINF/81, February 1991)

Introduction

Section 1: Introductory Tutorial: the BILKO 1.2 Image Processing Software

Section 2: Practical Lessons Using Image Data

- Analysis of a synthetic aperture radar image of the Straits of Dover
- Seasonal variation of phytoplankton distribution in the Arabian Sea
- Studies of South American coastal discharge using Landsat data
- Display and analysis of acoustic doppler current profiler (ADCP) data
- Wind-driven upwelling off the coast of South Australia
- Thermal structure of the southern Coral Sea

Section 3: A Lesson for Lesson Creators

Appendix: Contents of the floppy disks

Contents of Third Module (MARINF/83, February 1992)

Introduction

Section 1: Introductory Tutorial: the BILKO 1.3 Image Processing Software

Section 2: Practical Lessons Using Marine and Coastal Image Data

- 1: Extent and content differentiation of coastal plumes
- 2: Using Landsat for coastal management - 1: Mapping and determining major substrate categories
- 3: Using Landsat for coastal management - 2: Vegetation mapping
- 4: Detection of potential areas for coastal aquaculture using the Indian remote sensing satellite - IRS 1A
- 5: Study of coastal lagoonal features using IRS-1A LISS data
- 6: Temporal and spatial variations in sea-ice concentration in the Southern Ocean
- 7: Global waves and winds from Geosat
- 8: Ocean eddy dynamics generated by a numerical model

Appendices

- A: Contents of the floppy disks
- B: Contents of module 1 (MARINF/70) and module 2 (MARINF/81)
- C: Reply sheet for user response to UNESCO

Contents of Fourth Module (MARINF/90, July 1993)

Introduction

Networking

Section 1: Introductory Tutorial: the BILKO 1.3 Image Processing Software

Section 2: Practical Lessons Using Marine and Coastal Image Data

- 1: Imaging in-situ bio-optical and physical parameters
- 2: Spatio-temporal evolution of coastal upwelling in the Senegalese and Mauritanian littoral
- 3: Variation of AVHRR-derived sea-surface temperature with satellite zenith angles
- 4: Seasonal and yearly variation of surface temperature distributions in the North Sea
- 5: Analysis of the turbid plume of the Gironde Estuary (France) using SPOT data
- 6: Detection of sea-surface life with an Airborne Synthetic Aperture Radar
- 7: Bathymetry prediction from satellite altimeter data

Appendices

- A: Contents of floppy disks
- B: Contents of module 1 (MARINF/70), module 2 (MARINF/81) and module 3 (MARINF/83).
- C: Reply sheet for user response to UNESCO

Note: Module 4 is also available in **Russian** (see Module4r directory on the CD-ROM). Also downloadable over the internet from <http://www.dux.ru/csi/dosbilko/module4r.zip>.

**Contents of Fifth Module (MARINF/96, December 1995)
Originally issued in Spanish (MARINF/96, September 1994)**

Introduction

Section 1: Introductory Tutorial: the BILKO 1.3 Image Processing Software

Section 2: Practical Lessons Using Marine and Coastal Image Data

- 1: Identification and differentiation of coastal ecosystems
- 2: Principal characteristics of the area around the Lagartos River, Yucatan, México
- 3: Evolution of a coastal upwelling event at 30°S
- 4: Observation and analysis of a red tide event from NOAA/AVHRR images in the Argentinean Sea
- 5: Research on physiographic phenomena influenced by marine currents in the Terminos Lagoon
- 6: Thermal structures associated with the superficial, general circulation observed between Cape Verde and Freetown (North-West Africa)
- 7: Monitoring the coastal upwelling NW of Africa with AVHRR-APT images
- 8: Study of the distribution of suspended solids in the western coast of Maracaibo Lake (Venezuela), using Landsat data
- 9: Identification of physical processes favouring the development of phytoplankton, based on the colour characteristics of the sea

Appendices

- A: Contents of the floppy disks
- B: Contents of first module (MARINF/70), second module (MARINF/81), third module (MARINF/83) and fourth module (MARINF/90)
- C: Reply sheet

Contents of Sixth Module

Introduction

Section 1: Microsoft Windows: Getting started

Section 2: Introduction to *Bilko for Windows* 1.0 image processing software
Introductory on-line tutorials

Section 3: Practical lessons using marine and coastal image data

- 1: Deriving sea surface temperature maps from the ERS-1 Along Track Scanning Radiometer (ATSR)
- 2: Using Landsat for coastal management-1: Mapping and determining major substrate categories
- 3: Using Landsat for coastal management-2: Vegetation mapping
- 4: Imaging coastal features with ERS-1 Synthetic Aperture Radar (SAR); central English Channel

Appendices

- A: Files needed for Module 6
- B: Contents of first module (MARINF/70), second module (MARINF/81), third module (MARINF/83), fourth module (MARINF/90) and fifth module (MARINF/96)
- C: Reply sheet

REPLY SHEET

Seventh computer-based learning module on
Applications of Satellite and Airborne Image Data to Coastal Management

Name and address of respondent:

.....

Fax number:..... E-mail:.....

Respondent's discipline or interest (*): *coastal zone management/ socio-economics / environment / coastal planning / cultural issues / physical oceanography / marine biology / marine pollution / meteorology / hydrology / marine geology / other (please specify)*.....

- (a) I am / am not (*) in a position to contribute a lesson to a further module. If affirmative:
 - (i) tentative title
 - (ii) tentative date for first draft.....
 - (iii) what additional software function(s), if any, would enhance your lesson?

 - (iv) I would/ would not (*) like my lesson to make use of HTML or Windows hypertext functions.
- (b) I will/ will not (*) contribute additional material to enhance lessons in existing modules. If affirmative: *additional images/ alternative questions/ further explanations (*)* for lesson no..... in module.....
- (c) Among future lesson subjects, the following applications, phenomena, data or geographical area would be of particular interest to me and/or my students

- (d) I am using the *Bilko* software and modules for the following purposes (tick as appropriate):

Teaching	():	University level ()	High school ()	Other, please specify
Research	():	Please specify discipline		
Other	():	Please specify		

- (e) I recommend that a copy of the seventh module be sent to the following person(s) who is (are) likely to be in a position to contribute lessons to further modules:

- (*) Please delete or encircle as appropriate

Return to: UNESCO-Bilko Project Coordinator,
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